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Spring, 1945

"Let There Be Sight"

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Sight Restoration Through Corneal Grafting

R. Townley Paton, M.D.

THE author explains the subject of corneal transplantation and describes the Eye-Bank, its objectives and its aims and hopes.

WHILE there are no exact figures, it is estimated that ten thousand to fifteen thousand blind* people in the United States could have their sight improved through the operation of corneal grafting. In considering the subject, it must be realized first of all that this type of operation can restore sight in only one form of blindness—*i.e.*, blindness that is caused by opacity of the cornea when the rest of the eye and the optic nerve are normal. The technique of the present-day operation is so relatively new that few ophthalmologists have had an opportunity to acquire it. Another reason the operation has not been more frequently performed is the unavailability and difficulty of obtaining fresh tissue. These difficulties are to be overcome, however, by the establishment of the Eye-Bank for Sight Restoration, Inc., whose program will be described after a presentation of the pertinent facts, such as the history of the operation; the nature of the operation; causes of corneal opacities; types of cases which are operable; results of the operation; mechanics of preserving eyes from which corneal tissue may be used for the operation, etc.

History of the Operation

The first mention of the technique of the corneal grafting operation goes back more than one hundred years. Both Reisinger and Himly experimented early on rabbits, and Kissam of New York is said to have been the first to operate on man, using an animal cornea. In 1838 he used the cornea of a pig as a graft, but the opera-

* Blind according to the accepted definition of blindness, namely, 20/200 in the better eye with correction, or better than 20/200 if there is a defect which narrows the field of vision to 20 degrees or less.

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tion was a complete failure. Erasmus Darwin, as early as 1803, made the suggestion that the grafting operation might be possible "if the scar should heal without losing its transparency. Many blind people might be made to see tolerably well by this slight and not painful operation." Previous to this time, Pellier in 1789 attempted to make a substitute cornea out of glass supported by a circular gold band which was sewed to the eye in place of the diseased cornea. Von Hippel (1877–1886) was one of the first to bring about a lasting improvement in vision; and since then, up until the beginning of this century, isolated cases were reported, mostly from European clinics.

Zirm, using von Hippel's trephine, obtained an exceptionally successful case of keratoplasty (corneal transplantation). He removed a clear disc of cornea from an eleven-year-old boy whose sight had been destroyed by a fragment of steel, and transplanted it to the eye of a forty-five-year-old man whose cornea was almost entirely opaque as a result of a burn by unslaked lime. The transplant was held in place by two conjunctival sutures, and the graft healed rapidly. At the end of a year his vision was 6/36 with a stenopaic disc, and with convex glasses (20D) the patient could read J4 with difficulty. Zirm considered the following points essential to a successful operation: (1) The exclusive employment of human cornea for the graft, preferably the cornea of a healthy young person; (2) the exclusive use of von Hippel's trephine and the instillation of eserine if the anterior chamber is present; (3) profound anaesthesia during the operation, strict asepsis and the avoidance of antiseptics; (4) protection of the graft between pieces of gauze moistened with sterile physiological salt solution kept warm by steam; (5) retention of the graft in position by two sutures attached to the conjunctiva and forming a cross over it; and (6) selection of cases.

It is interesting to note how little the more modern technique has changed. The improvement has largely been brought about by a better understanding of the physiology of the eye, and the manner of protecting the graft, once it is in position. There have been some changes in methods of suturing and also in development of new instruments; it is now possible to cut grafts of an exact size, within a fraction of a millimeter.

The years* following Filatov's first case, in 1913, brought about a renewed interest in this subject, and by 1930 two or three hundred successfully operated patients had been reported upon. A careful follow-up on these patients cannot be found in the literature, and by 1938 only 150 cases were known to have maintained good vision for over a period of nine months. The work has been greatly helped by the improved technique of Thomas, in England, and Castroviejo, in this country. Although there are many eye surgeons capable of performing this operation, only a small number, ten or fifteen, have become experts in this special field of eye surgery. Few have done over 100 operations to date, in this country.

Nature of Operation

There are three surgical methods of removing corneal scars: (1) Total removal of the whole cornea and substitution of a cornea from some other eye; (2) partial penetrating corneal graft and the partial substitution of corneal tissue; and (3) complete penetration of a portion of the cornea and the substitution of healthy living tissue.

The first method has so far proven entirely impractical and the transplanted cornea has always lost its transparency in a few days. The second method has certain advantages in some types of corneal scarring, and a partial graft (not including all of the layers of the cornea) may bring about a material improvement in vision. The most dramatic improvement in sight and often the most successful results are obtained by means of the third type of operation—those cases where a complete window including the full thickness of the cornea is used.

The operation, for an experienced eye surgeon, is a relatively simple procedure. The cutting of the window out of the healthy cornea and the transplanting to a similarly cut hole in the cornea of the patient's damaged eye, may be done in twenty minutes. The graft is held in place by various means; usually delicate sutures are employed to hold the graft from shifting until healing has taken place. These sutures may be removed from five to eight days after the operation. The success or failure of the operation depends in a

* *Modern Trends in Ophthalmology*, written by Arnold Sorsby, and edited by Frederick Ridley and Arnold Sorsby, New York, Paul B. Hoeber Inc., 1944.

large measure on two factors: (1) Obtaining suitable healthy corneal tissue; and (2) exact and accurate cutting of the window so that a perfect fluid-tight fit is obtained.

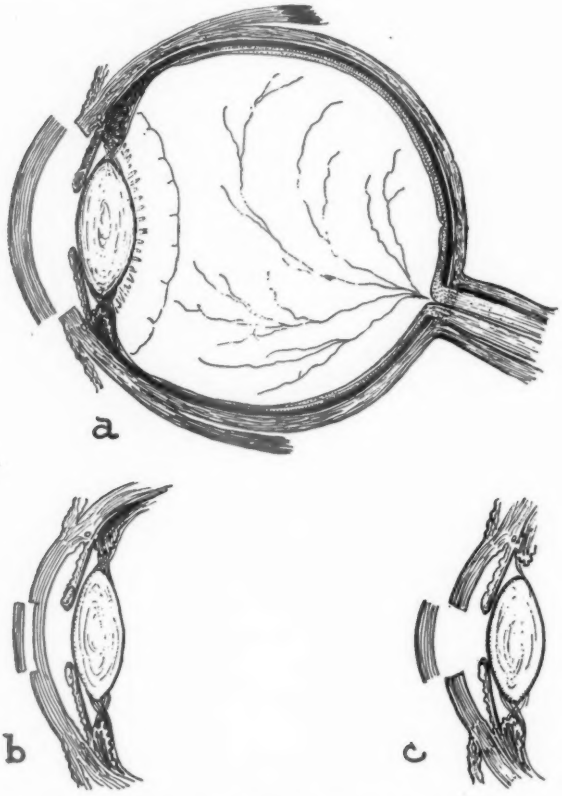

FIGURE 1.—SURGICAL METHODS OF CUTTING GRAFT: (a) Total removal of cornea and substitution of a cornea from some other eye; (b) partial penetration of cornea and the partial substitution of corneal tissue; (c) complete penetration of a portion of the cornea and the substitution of healthy living tissue.

Causes of Corneal Opacities

It is estimated that there are 250,000 blind people in the United States, of which number five to seven per cent are blind due to corneal scarring. Of this number of blind people, two per cent of

blindness in children, and one per cent of blindness in adults, are due to interstitial keratitis. No figures for other countries are available as to the number of people blinded as a result of corneal opacification, but it is a well-known fact that blindness from trachoma and venereal disease is over ten times more prevalent in European countries than in the United States. Trachoma invariably causes scarring of the cornea, and leads to blindness in a high percentage of poorly treated cases. In some countries trachoma is universal, notably along the southern and eastern littoral of the Mediterranean: Egypt, Palestine, Iraq, Iran, and Turkey; and Russia. In the latter country, 20.64 per cent of blindness is thought to be the result of trachoma.

Duke-Elder* has stated that "it is very common, involving from 30 to 60 per cent of the population in Arabia, Syria, the Sudan, Lybia, Tunis, Algeria, Morocco, Greece, large tracts of central Russia, China (here more than 100,000,000 are affected—T'ang 1934) and in Japan." It is found to be present in nearly all tropical and subtropical countries throughout the world. So important and prevalent was this disease thought to be that a special society for its study was formed at the Geneva League of Nations, in 1930.

Scarring of the cornea from gonorrhea and syphilis, with resulting loss of sight, may be helped and, in some cases, vision completely restored by the corneal transplant operation. Scarring and damage to corneal tissue may also result from a host of other conditions: industrial accidents, perforating injuries, thermal and caustic burns such as might result from lime, or acid burns. From many of the contagious diseases where the surface of the body is affected, as by measles, scarlet fever, etc., corneal ulcers may result and, when healed, leave a disfiguring scar and often the loss of vision in one or both eyes.

In the United States, it is maintained that of the estimated 22,000 blind with corneal scars about one-half will not be suitable cases for corneal graft operations, due to advanced age, secondary glaucoma, retinal, uveal or optic nerve disease, complicating the corneal disease. It may be estimated that roughly about 10,000 blind persons might avail themselves of the operation in the United

* *Text Book of Ophthalmology*, by Stewart W. Duke-Elder (Volume II, Page 1595), St. Louis, C. V. Mosby Company, 1934.

States. Probably—due to the absence of accurate statistics—a much higher number of persons would benefit by this operation.

Types of Operable Cases

Cases for operation may be classified into three groups: (1) Favorable for vision; (2) unfavorable for vision; and (3) for cosmetic effect alone.

The most favorable cases are those in which the intraocular tension is normal. There must be no active infection of the cornea, sclera, or conjunctiva. The corneal opacity must be central and not too dense. The clearer the area surrounding the central corneal opacity, the more favorable the prognosis. Cases may also be considered favorable in which there has been a recent but not too active interstitial keratitis, keratoconus, blood staining of the cornea, or some types of corneal dystrophy (faulty nutrition of the cornea).

The outlook is unfavorable when a dense leukoma extends over the entire cornea, with vascularization, or when the intraocular tension is raised, as in glaucoma. The outlook is also less favorable in cases of aphakia (absence of the lens of the eye). In calcareous degeneration and Fuchs' corneal dystrophy, operation should be attempted, although no permanent improvement in vision should be expected.

Cosmetic improvement may be expected in a few carefully selected cases in which tatooing was formerly resorted to.

Preservation of Eyes

For the present the safest means of preserving the eyes is in a moist physiological salt solution, at a temperature of three to four degrees centigrade, for about two days. Other means have been tried, such as preserving the eyes in hemolyzed blood serum, at a temperature of five to eight degrees centigrade. In one case the corneal tissue of an animal was kept alive for twenty-five days by changing the fluid once every five days. The full vitality of the tissue thus preserved was demonstrated by grafting it into the cornea of another animal of the same species. Tyrode solution and formalin have been used with some apparent success for the pres-

ervation of human eyes, but much research work on this subject still needs to be done. No doubt the time will come when corneal tissue may safely be preserved for several weeks.

Results of Operation

Though many of the early attempts at the operation were only partially successful, during the past ten years the results, so far as improvement of vision is concerned, have become permanent in about 80 per cent of the cases. From 1914 to 1930 Elsching and Ascher found that among all cases operated upon, 20 per cent remained permanently transparent and 23 per cent remained partially transparent, or translucent. In a recent series of 100 carefully selected cases, only two complete failures were met with. The improvement in vision from hand movements at 2 feet to 20/200 is not uncommon in carefully selected cases. A few cases have obtained 20/20 vision without glasses. In most of the successful cases the patients were able to read Jaeger 3 print, with correction.

After-care of Patients

The care of these patients follows the routine of cataract patients. Both eyes are kept bandaged for three or four days, and the sutures are removed from the fifth to seventh day; the patient is allowed out of bed in a week, or sooner, with the average hospitalization being from ten days to two weeks. The complications resulting from this type of operation are fewer than those following cataract extraction. Follow-up care is confined to weekly visits to the physician or clinic for a period of about a month; at the end of this time the patient is discharged unless complications have developed.

Establishment of an Eye-Bank

What is the Eye-Bank?—The Eye-Bank for Sight Restoration Inc. is an organization recently established to collect and preserve healthy corneal tissue from human eyes for transplanting to blind persons who have lost their sight because of corneal defects. It is national in scope, has been incorporated under the laws of New York State, and 32 leading hospitals in New York City are now affiliated with it. Initially, the needed space and personnel have

been made available in the Manhattan Eye, Ear & Throat Hospital. The Eye-Bank will acquire additional space, personnel and equipment as needed, so as to serve not only the New York area but localities throughout the country.

Objectives.—In brief, the objectives of the Eye-Bank are:

1. To establish sources of supply of salvaged eyes and corneal tissue; to establish an eye-bank for the collection, preparation, storage, and redistribution of salvaged eyes and corneal tissue.

Any eye which is sent to the Eye-Bank will have a complete pathological study made and a report sent to the institution which supplied the eye, on request; also bacteriological studies will be made for possible contamination, etc. Institutions desirous of making their own pathological examination will have the eye returned to them in the proper preservative fluid. There are naturally many smaller institutions that do not have the facilities for the proper pathological examination of eyes, and one of the purposes of the Eye-Bank is to encourage complete pathological studies of all eye tissues sent to it.

2. To encourage and extend, by teaching and research, the knowledge and skill required to perform the operation. Fellowships will be established when sufficient funds have been made available. Qualified eye institutions throughout the country may apply for these fellowships.

3. A subsidiary function of the Eye-Bank is to stimulate an interest in research work on blindness resulting from corneal damage for which fellowships and scholarships are to be established and distributed to qualified institutions throughout the country where this work can be performed.

Who Backs the Eye-Bank?—Albert G. Milbank, president of the Milbank Memorial Fund, has been elected chairman of the Advisory Council and Stanley Resor, president of the J. Walter Thompson Company, has been elected president of the Eye-Bank. Other officers are Dr. R. Townley Paton, vice-president; Cyril B. Hartman, secretary; and Walter C. Baker, treasurer. Mrs. Henry Breckinridge is executive director.

The National Society for the Prevention of Blindness and other public health and medical agencies are co-operating with the project.

The New York Chapter of the American Red Cross, through its Motor Corps Division, has taken the responsibility of transporting corneas between the Eye-Bank and its affiliated hospitals in the metropolitan New York City area. As the Eye-Bank obtains sufficient quantity of corneal tissue for national distribution in the future, transportation will be arranged.

Physicians who are participating, in an advisory capacity, are: Dohrmann K. Pischel, San Francisco, California; Colonel Derrick Vail, Washington, D. C.; Harry S. Gradle, Chicago, Illinois; Cecil S. O'Brien, Iowa City, Iowa; Alan C. Woods, Baltimore, Maryland; Theodore L. Terry, Boston, Massachusetts; William L. Benedict, Rochester, Minnesota; Lawrence T. Post, St. Louis, Missouri; Edmund Spaeth, Philadelphia, Pennsylvania; Lieutenant Colonel M. Elliott Randolph, Valley Forge, Pennsylvania; Purman Dorman, Seattle, Washington; and Conrad Berens, Ramon Castroviejo, John H. Dunnington, Daniel B. Kirby, John M. McLean, R. Townley Paton, E. Clifford Place, David H. Webster, and Herbert B. Wilcox, of New York.

Aims and Hopes.—In addition to handling the mechanics of supplying healthy corneal tissue, the Eye-Bank hopes to extend, through scholarships and fellowships, the knowledge and skill required to perform this delicate operation. Six thousand physicians are qualified to practice ophthalmology, of which four thousand also specialize in ear, nose, and throat. Perhaps less than one per cent of these physicians would be willing to acquaint themselves with the technique of the operation and post operative follow-up care of patients upon whom the operation has been performed.

Another of the Eye-Bank's objectives is to discover improved methods for preservation of the corneal tissue over a longer period of time than is now possible. At the present time, the corneal tissue taken from a living or dead person may be stored for only two to three days before it is transplanted. Corneas obtained from a dead person must be removed within a few hours after death. It is necessary to have the consent of the next of kin for a post-mortem removal of an eye, even though the deceased left written instructions for the use of his eyes in this way.

Incidentally, it is of interest to note that a cursory inquiry among prominent representatives of leading religions, indicated that there is no religious edict against the use of the eyes of dead persons. The only limitation mentioned was one in which the eye could not be sold or obtained for commercial profit. "It would not be permitted," the writer states, "for any commercial concern to be the transmitting agency. The only way in which the eyes of a person who had died could be used for the purpose you suggest, would be if a non-profit-making concern or the government were to undertake to see to it that the eyes taken from people who have died are used to restore the sight of the blind, and that no effort would be made to obtain the eyes of people who had died, unless they were essential for the cure of people who actually need them."

Some Public Health Aspects of Ophthalmology*

Frank W. Law, M.A., M.D., F.R.C.S.

EMPHASIZES the necessity for bridging the gap between the academic and clinical ophthalmologist and the social and industrial applications of his activities.

IN the days, now regrettably far distant, when one was being introduced for the first time to the intricate and absorbing facts and problems of the anatomy of the human body, a piece of advice was given to me by an astute demonstrator, in preparation for the periodical *viva voce* examinations of one's knowledge of the part which one was dissecting and studying; and that advice has remained with me ever since. It was to the effect that one should pay particular attention to the junctional areas. For the benefit of those present who have been denied the pleasure and instruction, immediate and philosophical, of dissecting the body, I would explain that the custom is to have assigned to one, particular parts of the body in turn—head, arm, thorax, and so on—for dissection. The term, junctional area, thus becomes clear—it is an area where one part (using the term in its applied sense) joins another, exemplified by the axilla, the inguinal region or groin, the diaphragmatic area, and the neck. The advice was good; for it will readily be understood that for the comfort of isolation and elbow room, one's early aim was to separate the part from the trunk, and there was therefore a real tendency for the junctional area to suffer relative neglect. When I was invited to deliver this lecture the application of the principle struck me at once. There is a section of the community well versed in the knowledge and problems of ophthalmology; there is a whole community waiting to benefit from this knowledge. It is in the liaison between the two, the appli-

* Published under the title, "Ophthalmology" in the *Journal of the Royal Institute of Public Health and Hygiene* (London), August, 1944—originally a lecture delivered at the Institute.

cation of this knowledge to everyday life, the bridging of the gap, the junctional area in the socio-scientific anatomy represented by the commerce between the informed part and the uninformed whole, which has hitherto in part suffered from neglect, and which offers such a fruitful field for endeavor. I am therefore extremely grateful, and here offer my sincere thanks, to the President and Fellows of the Royal Institute of Public Health and Hygiene, for the honor they have done me in inviting me to deliver this lecture upon my own subject, for I realize what an amount of co-operation is still needed before the benefits which could accrue from the application of the ophthalmologist's knowledge and experience to social, domestic, and industrial problems may be realized in full. I am very sensible of the responsibility which my position for a few moments today carries with it, and deem it a great opportunity if I can by even so little help forward the cause which I have outlined, and indicate a few directions in which mankind may further benefit from the application of the art and science of ophthalmology to problems of everyday life.

History of Ophthalmology in England

A brief reference to the history of this relatively young branch of medicine may not be out of place. Ophthalmology has been called the Queen of Specialties; I have wondered at various times in considering its position in hospital routine and in its application to everyday affairs, whether one might not more appropriately refer to it as the Cinderella of the medical household. Be that as it may, it is as I say a relatively modern specialty, having been considered, at least in its surgical aspect, a reasonable side-line for the general surgeon until the middle of the last century; and even today it is still, in parts of the United Kingdom, practised in conjunction with the surgery of the nose and throat. I cannot but feel, not only that such a combination is unfortunate in itself, but that as a subject ophthalmology offers ample scope for the ability and energy of any ordinary man.

It is obvious that the importance of sight, the fear of blindness, and the dramatic aspect of restoration of vision will at all times have made their particular appeal, and focussed attention upon the practice, and the practitioner, of the science of the function of the

eye. It will also be realized that the subject has always offered great scope for irregular practice, exploitation, and charlatanism, which cannot be said by any means to be extinct even at the present time. The science of optics and the application of lenses as an aid to vision, saw its beginnings in Britain in the 13th century. Perhaps the first sizeable treatise upon diseases and disorders of the eye was that of Richard Banister, which appeared in the 17th century; the same century produced Turberville of Salisbury, who was a qualified medical man in contradistinction to the majority of those who at that time were treating those suffering from eye disease. This majority were unqualified quacks, and an astonishing number of them there were, this state of affairs reaching its height in the 18th century, when the best known of such characters were William Read, Roger Grant, and the famous Chevalier Taylor, who has for long been a subject of particular interest to me. That these gentlemen were taken at their own valuation is evident from the fact that Read, though knighted by Queen Anne, belied his name in being unable to read, a quality which he shared with Grant. The Chevalier Taylor was no fool; furthermore, he was well in advance of his time in professional knowledge. His little weakness was that "he practised all the arts of unblushing effrontery and charlatanism." He was a surgeon oculist to King George II, and treated a great number of the nobles and personages of his time. His statements in reference to his past professional success were stupendous, for he cared nothing for accuracy, even historical accuracy, as is well instanced by his statement that he restored the sight of the great Bach (at whose hands, he states, Handel received his musical education) at the age of 88, and that he also operated upon Handel. As a matter of actual fact Handel was operated upon not by Taylor but by William Bromfield; Bach never attained the age of 88; he was blind after Taylor's operation, and Bach and Handel, contemporaries though they were, and in spite of their efforts to do so, never met. Taylor's already well-advertised arrival in a town was not only made in a splendid turn-out of coach and six, but was preceded by a band.

Early in the 19th century ophthalmological matters took a turn for the better; the year 1805 saw the foundation of Moorfields Eye Hospital, soon to be followed by the Royal Westminster and the

Central. By the mid-century all the five present London Eye Hospitals were functioning, and many provincial ones. Sound textbooks were produced and ophthalmic education in its modern sense began. In 1881 the great Sir William Bowman founded the Ophthalmological Society of the United Kingdom, an academic nonpolitical society. *The British Journal of Ophthalmology* appeared in 1917 incorporating into one publication the *Royal London Ophthalmic Hospital Reports*, the *Ophthalmic Review*, and the *Ophthalmoscope*, and has continued without break. In 1918 some senior members of the profession, realizing the necessity for a body which could, among other functions, provide a link between the academic and the industrial and sociological side, founded the Council of British Ophthalmologists.

Function of the Science of Ophthalmology

The main function of the science of ophthalmology must ultimately be the prevention of blindness. At the present time it is likely that the rate of blindness in England and Wales is of the order of 2.5 per 1,000, which for the 40 million inhabitants gives the impressive figure of 100,000 blind, the criterion of blindness for purposes of registration being "so blind as to be unable to perform any work for which eyesight is essential." Note that the definition states "any work," and takes no account of the person's fitness to continue in his or her previous occupation. An analysis of over 3,000 certified blind persons in the south of Scotland has recently been made by Marshall and Seiller, which contains some very interesting statistics. It is found that the three predominating causes of blindness are cataract, myopia, and venereal disease, which account together for 47 per cent of the total. Eugenists will be interested to hear that developmental and heredo-degenerative lesions account for under 8 per cent; it is somewhat surprising to learn that injuries account for even less than this, namely, 6.4 per cent. Analysis of the age distribution of the different causes of blindness reveals figures of still further interest: 68 per cent of blindness in the first four years of life is caused by ophthalmia neonatorum and congenital anomalies; the major causes in the school period are congenital syphilis and non-industrial injury; while syphilis is responsible for one-fifth of the total in the age-

group 30–49. This disease is the most important single cause in the age-group 16–29; here the figures for injuries, chronic septicemia, and myopia are also high. Degenerative lesions, myopia, cataract, and glaucoma naturally rank high in the later age groups. It is evident that such an analysis would be of extreme value in the approach to the sociological aspect of the prevention of blindness.

While great advances have been made in the battle against ophthalmia neonatorum it is evident that there is still scope for further work, though it must be remembered that the advent of the sulphonamide group of drugs will undoubtedly be found to have revolutionized the relevant figures quoted above. There are difficulties in the approach to the problem, since in the lay mind lingers the conviction that a stigma attaches to the parent of a child suffering from this complaint. Infection occurs either prenatally, or more normally from the birth canal in the process of birth; it may also occur after birth. It is especially to be noted that the statutory definition of ophthalmia neonatorum is entirely independent of the bacteriology of the condition, and a wide ventilation of this fact would go far toward reducing the difficulties of those attempting the early recognition and treatment of the disease. Incidentally, though percentage figures are very difficult to compile and evaluate, it would appear that the numbers caused by venereal infection are relatively low. As a concrete example of what a prophylactic measure can achieve, one can profitably study the effect of the introduction of the Credé method of prevention of this infection. This method, which consists in immediate cleansing of the baby's eyes, and instillation of 1 per cent or 2 per cent silver nitrate, was introduced in the early 1880's before which date ophthalmia neonatorum was responsible for 40 per cent of blindness in blind schools. It is safe to assume that the practice was by no means universal, nor always efficiently carried out, but the effect of its introduction was to cause a profound drop in the percentage of children blind from this cause. I regret that I cannot give you the actual figure, but a conclusion can be drawn from the fact that now 50 per cent of blind children are so on account of malformations and hereditary anomalies, leaving 50 per cent to be divided amongst the multitude of other causes, which includes ophthalmia neonatorum.

Ophthalmology in Relation to Industry

The number of angles from which the science of applied ophthalmology impinges upon industry and the industrial worker are legion, and, though this may not represent the potentially most useful field for liaison and co-operation, in the prevention of actual blindness, it is none the less one in which there is great opportunity for the prevention of accidents, the increase in comfort and efficiency of the worker, and the consequent amelioration of the public health in general.

Safeguards.—Actual injury to the eye in this field arises most commonly from the reception of foreign bodies or from exposure to radiation, visible or invisible, of such a wave-length as has a pathological influence on the various tissues of the eyes. There is, broadly speaking, one common method of preventing all such injury, and that is by the use of protective goggles or screens; there is, and while human nature remains unchanged there always will be, one constant obstacle to the universal adoption of such measures, and that is the rooted aversion of workers to the use of such protective apparatus. Recently a Surgeon Rear-Admiral, in a lecture upon facial burns through bomb and shell-flash on board ship, made the interesting statement that the vast majority of such burns were received from ships which had not hitherto provided casualties from such a cause—after which the admittedly cumbersome but entirely efficient protective clothing and hood were consistently worn by all liable to exposure to flash, with immediate effect upon the casualty rate.

In a visit to a factory turning out heavy munitions, I watched with interest the workers, in this case women, employed in arc welding—a process which generates a high percentage of dangerous ultraviolet rays. All these workers were provided with protective glass screens through which the job—which is the term they use for the actual metal parts upon which they are working—should be viewed during the process. Practically without exception the worker looked round the side of the screen at the moment of "striking the arc"—the moment when the brilliant light is first generated and incandescent foreign bodies are more liable to be thrown off—after which he retired behind the screen. Pointing out the potential

danger of this habit I enquired why they indulged in it; the reply was that they knew it was risky, but that it was easier to see the job that way.

A vast number of protective goggles and shields have been prepared and exhaustively tested, adapted to suit every purpose, and always with due care for comfort and convenience. Special chemical and colored glass goggles are also required to protect such workers as glassblowers, smelters, and puddlers, from the infrared rays which are liable to produce cataract if allowed to fall upon the unprotected eye. I believe the trouble in persuading the worker to wear such protective goggles is less than in those cases where the goggles are provided for protection from flying particles, where they are more frequently composed of fine gauze or plastic material. The occupations which demand such protection are, of course, many, and include grinding, turning, the use of hammer and chisel, or indeed any occupation which entails the striking of metal on metal; the emery wheel is one of the most familiar causes of a foreign body on the eye. The degree of severity, and potential danger of the accident is, of course, infinitely worse when perforation of the globe has occurred, either with or without the retention of an intraocular foreign body, and here lurks the danger of sympathetic ophthalmia. Any eye which has suffered a penetrating wound may become affected by a plastic intraocular inflammation which sets up, by a process not yet fully understood but most probably having an allergic basis, a similar inflammation in the undamaged fellow eye. The danger is grim and ever present, and hangs like a sword of Damocles over the head of the unfortunate patient, and incidentally also that of the unfortunate surgeon responsible for the case. While clinical experience is valuable in arming one against the possibility, the condition may none the less arise in any type of case, in a period after injury which ranges, to judge by the recorded cases, from 14 days to 25 years. A further difficulty in such a disease arises from the fact that, once it is present, excision of the exciting eye may have little or no effect upon the course of the disease in the sympathizing eye—indeed, the latter may progress to a worse state than the former, rendering necessary the most careful consideration before excising an injured eye when once the condition is established. It is my belief, however, that sympa-

thetic ophthalmia never occurs after excision of the potentially exciting eye, unless signs were present before the excision; it was my rule during the worst air-raid period, when clinical decisions had to be somewhat modified by existing conditions and when one could not see one's cases of injury regularly or frequently, to excise any injured eye in which the chance of useful vision seemed slight, if such an eye had not made obvious and advanced steps toward recovery in two weeks from the receipt of the injury.

There is, of course, possible danger to sight in the non-penetrating wound, even in the superficial corneal foreign body; prompt and efficient treatment, if protective measures have failed or have not been utilized, undoubtedly saves many eyes from loss of sight or even actual destruction. As an instance of this I would quote to you one result of the last great fire of London, during the night of which over 120 firemen came to the casualty department of Moorfields for the removal of ocular foreign bodies. Not one returned—I am not going to tell you, as in the parable, how many returned to give thanks!—not one returned subsequently for treatment, from which one may safely deduce that the prompt treatment afforded was successful in preventing any untoward after-effects, infective or otherwise.

My plea, at this juncture, then, is for more and greater efforts on the part of those in authority to persuade the worker in these particular industries to wear the protective apparatus provided. The attitude of the employer is usually enlightened and his cooperation ready; sometimes, however, one comes across evidence of a less open-minded attitude, as in the case of a worker with a pickaxe, who came to one of my hospitals with unmistakable clinical evidence of an intraocular foreign body. By the time I saw him, unfortunately, infection had occurred and the eye was past help—it would even have been dangerous to remove it, since infection had also spread to the orbital tissues, forbidding section of the optic nerve with consequent opening up of the meningeal sheaths. I was, therefore, compelled to eviscerate the globe, leaving the sclera intact. Over the resultant mass of infected and disorganized intraocular tissue I moved a small hand magnet, and was rewarded by the finding of a minute magnetic steel fragment, not more than a millimetre or two in any direction. The man in due course rightly

applied for compensation as the victim of an industrial accident, his application being backed by a clinical report from me. I was astounded to hear later that his firm had contested the claim on the ground that their representative had examined the pickaxe in question and could find no evidence that any portion was missing! I take no little pride in the fact that my letter to them, containing comments on their attitude, apparently dissuaded them from taking the case to court.

Those occupations which involve the generating of rays which may be harmful to the ocular tissues form a smaller but no less interesting group. The dangerous rays are those which occupy a position on either side of the visible spectrum, which ranges in wave-length from approximately 4,000 Angstrom units in the yellow to 8,000 in the red. (An Angstrom unit equals one ten-millionth of a millimetre.) The ultraviolet rays occupy a position from 4,000 to 1,000, when they approach the X-rays; the infrared rays from 8,000 to 4×10^6, where they approach Herzian and wireless waves. The action of these two sets of waves, which possess the common feature of being potentially dangerous to ocular tissues, is fundamentally different, that of the former producing a chemical or abiotic lesion, and that of the latter a thermal lesion or burn. Ultraviolet damage is likely to occur among such workers as welders, and any who are compelled to work in the glare of powerful arc lights. Protective goggles are an effective preventive, though these are obviously unsuitable for the cinema actor, for whom special care has to be taken to prevent as far as possible the direct incidence of the rays upon the eyes. Damage is most likely to occur to the cornea, though prolonged exposure to abiotic rays may produce deleterious effects upon the lens.

The thermal lesion from infrared radiation is more likely to occur among such workers as glassblowers, iron-puddlers, chain-makers, and so on, and in this case the lens is the vulnerable site, radiational cataract being produced. The protective measures to be adopted are similar to those of the previous group.

There are, again, occupations which involve the use of chemicals which on absorption may cause deleterious effects on vision. These chemicals include lead, carbon disulphide, and nitrobenzol, and special care is necessary to protect workers in processes involving

the use of these. The number of drugs which may adversely affect vision when taken by the mouth is, of course, much greater; into this group fall quinine, sodium salicylate, iodoform, naphthalin, antipyrine, santonin, and many others. Loss of sight has been reported in those taking medicines intended to produce a slimming effect; while finally in this category we must not forget the potentialities for destruction of vision possessed by those more common social and domestic lubricants, alcohol and tobacco.

Lighting.—In spite of the interest shown and the work done in the field of industrial and domestic lighting, very much remains to be done, and it is my impression, which I would rather hope is mistaken, that the unsatisfactory lighting conditions under which many people work and suffer are due, not so much to the difficulty of the problem they present, as to the lack of liaison between those willing to advise, and those anxious to learn and improve. There is an active, up-to-date body, the Illuminating Engineering Society; this body has now, at the instigation of an ophthalmologist, a standing Physiological Committee. None the less I maintain that a great number of workers labor under illuminating conditions which leave a lot to be desired, though it is probably true that the worker in a large factory is better considered from this angle than one in private employ. It has lately come to my notice that municipal bodies are taking an interest in the illumination of offices in this city, but in a rather misguided fashion. A patient upon whose eyes I recently operated returned to me complaining that, although he appeared to have completely recovered from the operation, he was unable to continue with his previous work, which was that of a bank clerk. It transpired that in his temporary absence the local authority had sent a representative round the neighborhood of his office, who had insisted, upon grounds of economy, on the substitution of the electric bulbs then in use, by bulbs of lower wattage. I submit that reducing illumination below the limits of efficiency in order to save what must be a relatively negligible quantity of fuel, represents a very false form of economy, the exercise of which should not be within the unsupervised power of a municipal department or body. This is not the place to enter into physical and physiological details on the subject; suffice it to say that the sooner it is universally realized that adequate and carefully planned illumi-

nation for every occupation is the right of the worker and the responsibility of the employer, so much the sooner will the efficiency, happiness, health and well-being of the majority be enhanced. Further, it is not a question which can be solved in the light of nature or by rule of thumb; I venture to suggest that anyone who has not studied the matter would be amazed at the complexity of the problem and the advances which have been made toward its solution. It is by no means merely a question of intensity of illumination which calls for attention, but (to mention but two of many aspects) such questions as glare, which may be defined as light in the wrong place, and the compensation for lack of help from shadows in working upon monochromatic fabric in diffuse illumination, provide examples of the many special problems which arise. Gone are the days when it is permissible for anyone to consider it reasonable to seat a dozen girls around a table to do fine sewing with the aid of the centrally hung unshaded, inadequate lamp.

As with industrial, so with domestic lighting, the difference being that here the remedy is in the sufferer's own hands; yet how often do we find conditions far from perfect. The explanation, in my opinion, lies in the fact that while the actual problem of illumination, as such, in industrial conditions is complicated and difficult, in domestic conditions further complications arise when the illumination may have to serve different purposes for different people in the same room. Nothing is more restful and socially conducive than to converse in a subdued illumination; nothing is more irritating and harmful than to attempt to read, work or sew, in the same conditions in the same room. The solution of the problem is certainly outside the scope of the average householder, and lies in the province of the illuminating engineer, who probably solves it by the provision of a diffuse general illumination augmented by local and more focal lighting for individual requirements, due attention being paid to the adequate shading of the illumination of the local areas from the eyes of those others in the room for whom it is not intended. The whole subject is full of difficulties and surprises; as an example of the latter it is most interesting to note the strange cheerless effect produced in domestic surroundings by intense diffuse or indirect illumination—an effect doubtless due to our

reaction against the immediately appreciated anomaly of the absence of shadow in a high intensity of illumination. A further instance of unanticipated effects arose when I was advising one of the larger gas companies in a matter of street lighting—which constitutes yet another division of this vast subject of illumination in general. Here we found that a good street illumination which contained a fairly high percentage of ultraviolet light (and I may mention in parenthesis that no real danger is involved in such kind of illumination, provided the source is behind glass) while possessing some advantages over the more usual types of illumination, produces a most disconcerting corpse-like effect upon the appearance of a person wearing any considerable amount of pigmented make-up. The matter assumes serious proportions when the essentially decorative social function of the female sex is considered; one is even in some doubt as to the side from which the problem should be tackled!

Function of Eyeglasses

No consideration of the public health would be complete without the inclusion of the question of examination for and provision of spectacles. In spite of the protests of so many of our patients that they are nothing but a nuisance, the fact remains that they are not only, as the motto of a well-known city company has it, "a Blessing to the Aged," but also a blessing to a vast number of all ages. Indeed it is not too much to say that life as we know it today would be impossible without them.

The origin of spectacles as an aid to vision is not certainly known, either as to time or place. There are reasons for believing that the 13th century saw the beginnings, and there is even evidence of the existence of a single originator of the apparatus. This is found in the inscription over the tomb of a native of Florence and reads as follows: "Here lies Salvino D'Armato of the Amati of Florence, Inventor of spectacles. May God forgive him. A.D. 1317." It is important to be careful, in assessing the date of the origin of spectacles, not to be misled by taking as evidence the depicting by an artist of a figure wearing spectacles, for many anachronistic errors have thus been made. Many of the saints have been represented wearing spectacles—the Church of St. Jacob, in Rothenburg, pos-

sesses a picture showing St. Peter thus equipped—and I have a drawing of a sculptured group by Thadaus Stammel in the Benedictine Library at Admont which includes the Devil himself wearing spectacles.

Intimately bound up with the question of spectacles is the ancient and somewhat controversial one of the relative positions of the medically qualified and the medically unqualified prescriber—in other words, the ophthalmic surgeon and the sight-testing optician* (as contrasted with the dispensing optician or spectacle-maker). As I say, a controversial subject; the ice is admittedly thin, but if you do not follow me too closely I think it will bear. The whole question turns upon whether it is to the patient's interest to allow the examination of the eyes—that is, the general examination which is essential to avoid neglecting the possibility of unsuspected eye disease, before ever the question of spectacles arises—to be carried out by unqualified persons, and also whether the prescribing of spectacles should be left to those who have a financial interest in their provision. As in so many similar problems, the issue has been clouded and a wrong atmosphere engendered by wrong approaches. The medical profession feels that the care of the eyes should be in medical hands, and that medical knowledge is usually necessary before it can be decided that it is "only a question of glasses." On the other hand, once the decision has been made, the actual examination of refraction, muscle balance, and other relevant investigations, can well be carried out by a skilled and properly taught technician; further, there are not enough ophthalmically qualified medical men in the country to serve the whole community in this way. The problem is under active consideration—perhaps more active than ever before. I think it is true to say that the majority of present-day ophthalmologists consider that a solution could be found in the employment in hospitals of properly trained, medically supervised opticians; schemes for the suggested implementation of this idea are in process of preparation. Not only would this, in time, solve a tricky problem, and also we hope result in the complete disappearance of the chemist or jeweller with a small side-line in the form of an optician's business, but it

* The British term, "sight-testing optician" is comparable to the American term, "optometrist."

would also help toward what is in my opinion a most desirable modification of the function of the ophthalmic surgeon in the hospital out-patient department—it would set him free to devote his time to the clinical and surgical aspect of his subject, to the benefit of the development of this aspect, and also to its teaching to the undergraduate and graduate student. It is my earnest hope that the interests of the public, the ophthalmic surgeon and the optician may be reconciled by the implementation of some such scheme, which will need the active co-operation and good will of all parties concerned, which include municipal authorities, insurance companies, approved societies, and the Ministry of Health. Not only would its adoption result in the solution of the public problem as to whether the provision of spectacles is or is not a medical matter, but it would also introduce the improvements which I have detailed and many that I have not. Upon the question as to whether it is desirable for the public to be able to purchase inferior spectacles under no kind of supervision whatever in a chain store, I do not feel compelled to dwell.

Eye Exercises

There has in the past year been a recrudescence of interest in the relatively though not equally old question of the improvement and preservation of sight by exercises; its appearance in the world of literature has caused some notice and correspondence in the popular press. Confusion has been introduced by the well-disseminated and perfectly correct knowledge that ophthalmology itself shows definite interest in eye exercises, and that this aspect of the specialty has made considerable headway in the past 30 years. Apart from the obvious point that it is important to be in a position to decide whether a patient needs such therapy, or only such therapy, the matter may perhaps be summed up in the trite sentence, "There are exercises, and exercises."

Orthoptic exercises have a real place in ophthalmology; but much of the misapplication of eye exercises in general arises from a fundamental misconception. There are two main sets of eye muscles: those which move the eyes as a whole, and which by means of a complex and marvellously integrated mechanism direct the center of vision toward that object to which attention has

been called; and those which subserve the function of accommodation, or focussing the eye as an optical instrument. The first set are properly termed the extrinsic ocular muscles, the second the intrinsic, which set includes those fine iris muscles which regulate the size of the pupil, or aperture as the photographers would call it. Hypermetropia, or long-sight; myopia, or short-sight; and presbyopia, the term applied to that relative failure of focussing power which becomes manifest for the first time in middle life, are the concern of the intrinsic musculature, and are naturally the functions in which the lay mind is most interested; yet it is the extrinsic musculature with which the majority of popular exercises deal. With the psychological value of such exercises one cannot at this juncture deal; it is a real value, and it is in this direction that the practitioners of these methods should look for most of their successes. This distinction I have drawn may serve a purpose in attracting attention to what is rightly considered a fundamental fallacy.

Orthoptic exercises, as directed by the ophthalmologist and practiced by the orthoptist, are a very different matter. I never tire of emphasizing that what they are really exercising is the brain, for the faculty of fusion of the binocular images resides in the higher centers, and it is this faculty, its cultivation and stimulation, or exploitation, with which orthoptic exercises are mainly concerned. The majority of cases to which such exercises apply are cases of error of muscle balance, apparent or latent. In the apparent condition, a squint is present, and both eyes are not directed toward the same object; in the latent, an inco-ordination is present which would prevent both eyes from being directed toward the same object, were it not for a constant subconscious muscular effort. The benefit to be derived in the former case is either functional, or cosmetic, or both; that in the latter consists in the relief of symptoms such as eyestrain and headaches.

I would not like it to be thought that I hold a poor opinion of orthoptic exercises given by an expert in appropriate circumstances, and it is for this reason that I have given you the distinction in some detail. It is important to direct attention to the two separate and distinct aspects of the problem of squint—the functional and the cosmetic. It is a relatively easy matter to operate

upon a squint and achieve a cosmetically satisfactory result; but only by the merest chance would such a result carry with it the effect of converting the previously functionally one-eyed patient into a functionally two-eyed one, possessing binocular vision with all its attendant advantages of binocular depth perception, stereopsis, and so on. Further, the chance of the cosmetic result remaining permanent throughout life is infinitely greater, as will readily be understood, if the binocular faculty is there, waiting to lock up the eyes, as it were, into a functionally single instrument. It is here that the value of orthoptic exercises is realized; given in suitable cases before operation, to stimulate the binocular faculty, and afterwards to educate it, they form a most valuable adjunct to surgical treatment. In some cases, indeed, so strong is the urge to utilize the binocular function that surgery can be avoided altogether. Per contra, it will be evident from what I have said that the effect of exercising the extraocular or extrinsic musculature in cases of refractive error, incipient glaucoma, cataract, or the host of other diseases in which such exercises have been applied, will be precisely nothing; and the time so occupied will not only be wasted but may constitute a dangerous delay in bringing the patient under appropriate treatment, seriously prejudicing the chances of a successful issue, and permanently endangering the patient's sight. The popularity of these unqualified practitioners is only another example both of the immense field, already referred to, which defective vision and ocular symptoms open up for exploitation by the specious charlatan, and also of the apparently inevitable fascination exercised upon the lay mind by plausibility and unorthodoxy. The honest conservatism of the medical profession, so often the subject of satirical comment, constitutes, did they but know it, one of the greatest safeguards of the health of the general public.

Summary

My first interest on recovering from the invitation to address you, Mr. Chairman, was to discover upon what aspect of my subject I was asked to speak. My reaction on learning that my title was to be the simple, all-embracing one of "Ophthalmology" was complex. Ophthalmology is my life's interest and will constitute

my life's work; it is my professional wife to whom I am wedded; it is my stern task-master; it is my bread and butter. How easy then to devote an hour to its exposition! But then I realized, as soon as I put pen to paper, that there was just where my difficulty lay; not where to begin, but where to end. The solution lay, as in most things in our land—nay, as in life itself—in compromise. I am no Solomon, but you are the Queen of Sheba—and "behold, the half is not told you." I have not even touched upon an aspect of the subject which has been so near us for the past five years—for war, with its injuries, its malnutrition, its disorganized medical services and health services, its epidemics, has been rightly described as the greatest single cause of blindness. What I have attempted to do is to point out a few of the aspects of my subject which are of particular interest in the sphere of public health and hygiene, and to hint at the necessity for further and greater effort in bridging the gap between the activities of the academic and clinical worker and the social and industrial applications of his activities—to revert to our anatomical simile, to turn attention to the junctional areas. If I have interested you this afternoon, I am amply rewarded; if anything I have said has the effect, however ultimate or however remote, of reducing ocular discomfort, increasing visual and general efficiency, or of saving even one of our fellow citizens from threatened or actual blindness, my time has indeed been well spent.

Elementary Illumination for the Ophthalmologist*

LeGrand H. Hardy, M.D., and Gertrude Rand, Ph.D.

WHAT the ophthalmologist should know about lighting is described briefly but fully by the authors.

POOR illumination produces ocular symptoms. The ophthalmologist is frequently consulted with regard to these symptoms, and he should be able to recognize and treat them effectively. He should, in addition, be prepared to do his part in preventing, as well as in ameliorating, conditions which might cause such symptoms.

The scope of such activities may vary from simple, obvious advice to full scale co-operation with the illuminating engineer, the architect and the decorator. With his understanding of individual differences and needs, his freedom from commercial bias and his awareness of the part played by good lighting in the comfort and welfare of the eyes, the ophthalmologist occupies an important position in this phase of public health service. The purpose of this brief report is to outline the basic facts and principles of good lighting so that the ophthalmologist may be well guided in his individual or co-operative efforts to alleviate or avoid distress arising from defective illumination.

Lighting Terms and Units

The ophthalmologist is not concerned with the rigid mathematical and operational expressions used by radiation engineers. To him lighting is the science of creating and distributing light, which he describes as radiant energy evaluated according to its capacity to produce visual sensation. Since all practical sources of light include neighboring bands of radiations (infrared or ultraviolet), these

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portions of the spectrum are included in his considerations as coincidental factors and are evaluated physiologically. Light (a temporal concept) and illumination (an areal concept) are not differentiated. One may overlook this lack of rigor, without condoning the meaningless phrase "footcandle power," so often encountered in ophthalmologic writings.

It will greatly facilitate the problem for the ophthalmologist if he will adopt three simple concepts:

1. **Source.**—The source of light is evaluated in terms of power of which the candle (c) is the unit.

2. **Illumination.**—The illumination at the working plane is evaluated chiefly with reference to the distance of the working plane from the source.

3. **Brightness.**—This term, again a power term, may refer to the source itself (intrinsic brilliance, expressed as candles per square centimeter or per square inch or per square foot) or to light reflected toward the eye from an object.

Simple units to express measurements of these three factors may now be derived.

Source.—The candle is the unit of luminous intensity. As a power term it expresses the intensity of the source. It is an antiquated concept, dating from the earliest attempts at evaluation and control of lighting. The old English sperm candle (six to a pound), which burned at the rate of 120 grains of spermaceti per hour, was taken as a standard. This standard has now been conserved by international standardizing laboratories in terms of incandescent lamps.

This candle flame emits luminous, or light, flux in all directions. The amount of this light flux encompassed in a unit solid angle (steradian) is the unit called a lumen. If the candle flame is condensed to a point and this point is situated at the center of a sphere with a radius of 1 foot, the amount of light falling on 1 square foot of the sphere is 1 lumen; and since the area of such a sphere is 4π square feet, there must be 4π, or 12.57 lumens, emitted by 1 candle.

Illumination.—Illumination is the intensity of concentration of light falling on a particular surface, and one unit of measurement is

the footcandle (ft. c). The footcandle is defined as 1 lumen per square foot. In the example chosen, since every part of the sphere is 1 foot away from a source of 1 candle power, each square foot of the sphere receives 1 lumen, and the illumination is 1 footcandle.

If the surface were not spherical, but were a plane tangent to the sphere, the illumination would be 1 footcandle only at one point on the plane, and it would be less than 1 footcandle on all other points, the intensity depending on the distance from the point source of 1 candle power and the angle of incidence.

It is thus seen that the illumination (which means intensity of light flux, and hence the phrase "intensity of illumination" is redundant) varies with three factors: the power of the source, the distance from the source, and the angle of incidence. However, these three factors operate differently. It is worth remembering that the illumination varies directly with the power of the source; that is, if a 2 candle power lamp is substituted for a 1 candle power lamp, the illumination is doubled. This is a direct proportion.

The variation with distance is not direct; illumination is inversely proportional to the square of the distance from the source. This is the inverse square law, applicable to all radiation, and it means that in order to obtain the same illumination at 2 feet as at 1 foot the power of the source must be increased by 2^2; or, again, a 100 candle power lamp which gives an illumination of 100 footcandles at a distance of 1 foot gives at a distance of 2 feet only $\frac{100}{2^2}$, or 25, footcandles, at a distance of 5 feet $\frac{100}{5^2}$, or 4, footcandles and at a distance of 10 feet $\frac{100}{10^2}$, or 1, footcandle. This is an important consideration and is the chief reason for supplementing general room illumination with local fixtures. It should be noted in passing that the inverse square law applies rigidly only to point sources and practically is valid only for long distances when large sources are used. It is invalid when the distance is less than five times the dimension of the source. Thus, the illumination from large luminaires or from nearby tubular lamps needs to be measured, rather than calculated.

Finally, if the light does not strike the surface perpendicularly but is incident at an angle, the same amount of flux is distributed over a larger area, and the illumination consequently decreases. The

amount of the decrease can readily be shown to be equal to the cosine of the angle of incidence. This is known as the cosine law.

Brightness.—It is obvious that only the light which enters the eye is useful for seeing and that unless one is looking at self-luminous objects this light must be reflected. The amount of light reflected from an object will vary with the amount of light incident on it and with its physical characteristics (reflectance). A white object with high reflectance will appear brighter under a given illumination than a dark object with low reflectance. The ratio (percentage) of the amount of light reflected from an object to the amount of light incident on the object is a measure of its reflectance and determines its brightness.

The simplest expression of brightness in terms of the units we have derived is the apparent footcandle. If an object is illuminated with 100 footcandles and has a reflectance of 80 per cent, 80 of these 100 footcandles will be reflected back, and the object will have a brightness of 80 apparent footcandles. In England the term equivalent footcandles is used. Or brightness can be expressed in terms of lumens per square unit of area. If 1 lumen is emitted or reflected from each square centimeter, the area has a brightness of 1 lambert (L). This is very high brightness, and for most practical situations a smaller unit is desired. Such a unit is the millilambert (mL), or 0.001 lambert. If the unit area is taken as the square foot, a surface emitting or reflecting 1 lumen per square foot has a brightness of 1 foot lambert (ft. L). Since there are $\frac{1}{1.076}$ sq. cm. in 1 square foot, the foot lambert equals 1.076 millilamberts, that is, the foot lambert, the millilambert and the apparent footcandle, as expressions of brightness, are practically interchangeable.

A point which often puzzles the ophthalmologist is why the brightness of an object does not noticeably decrease as one recedes from it. We have frequently been asked, for example, what the illumination of a test chart is to a patient 20 feet (6 meters) away. It is a fact that brightness as a sensation does not obey the physical law of inverse squares, but is practically independent of the viewing distance. The explanation of this is that the size of the retinal image varies inversely as the square of the distance, just as does the amount of light reflected from the object. The two are thus in com-

pensating relationship, and the unit density of light in the retinal image is independent of distance for a constant size of pupil. In other words, with increase of viewing distance the smaller amount of light entering the eye is concentrated into a proportionately smaller retinal image, and the projected image is therefore of approximately the same brightness whatever the viewing distance. There should be little change of brightness for different distances of viewing if the size of the pupil of the eye is maintained at these distances.

In estimating illumination the beginner may be perturbed by the fact that whereas the units and principles so far discussed use the candle as a basis of power, most lamps at present are rated in terms of watts. This difficulty can be lessened by considering the rated luminous efficiency of lamps and the luminous efficiency of the candle. Most incandescent sources used at present for illumination are tungsten filament, gas-filled (type C) lamps. They are rated both in watts per spherical candle power and in lumens per watt. The lumens per watt rating is about 11.5 for the 75 watt size, 14 for the 100 watt size and 16.1 for the 500 watt size. Since the most commonly used lamps are the 75 to 100 watt sizes, 12.5 lumens per watt may be taken as a rough average. As has previously been noted, a standard candle emits $4\pi = 12.57$ lumens; hence in this range (75 to 100 watts) 1 watt may be taken as equal to about 1 candle power. Such approximations as we have suggested are frequently used in illumination surveys, in which precise calculations are neither worth while nor desirable. After all measurements or estimations have been made, it is usual to add as much as 50 per cent to estimated requirements because of the progressive deteriorating influence of soiled walls, ceilings and other reflecting surfaces, the gathering of dirt on bulbs and fixtures and the loss of efficiency due to aging of lamps.

The elementary concepts of lighting units and terms may be summarized thus:

1. Sources of light are rated in power terms, the unit of which is the international candle. Light sources are rated in terms of candle power or watts. For 75 to 100 watt type C lamps, 1 watt is roughly equal to 1 candle power.

2. Luminous flux is a photometric quantity, the unit of which is 1 lumen. One lumen is defined as the quantity of light required to illuminate 1 square foot to an average intensity of 1 footcandle.

3. Illumination is a photometric quantity, expressed in terms of lumens and areas.

1 lumen per square foot = 1 footcandle (ft. c)
1 lumen per square meter = 1 lux (lx)
1 lumen per square centimeter = 1 phot (ph)
1 footcandle = 1.076 milliphots = 10.7 lux

4. Brightness is a photometric quantity, expressed in terms of lumens and areas. Its unit is the lambert, defined as the brightness of a perfectly diffusing surface emitting 1 lumen per square centimeter.

1 lambert = 1,000 millilamberts (mL)

An apparent footcandle, an equivalent footcandle and a foot lambert are terms for brightness describing the brightness of a perfectly diffusing surface emitting 1 lumen per square foot.

1 foot lambert
1 apparent footcandle
1 equivalent footcandle
} = 1.076 millilamberts

5. Intrinsic brilliance is a photometric quantity, expressed in terms of candle power and area. Its unit is the candle power per square inch. It is usually applied to source or transmitted light, rather than to reflected light.

Photometry

The measurement of illumination is based fundamentally on the inverse square law of spread of illumination (fig. 1). Two fields are presented to the eye for comparison, the illumination of one of which is known and that of the other is to be measured. By a comparison of the squares of the distances of the two sources, it is a simple matter of arithmetic to compute the value of the unknown illumination. Adjustment is made of the distance of one of the two sources of illumination until the two fields are judged to be of equal brightness. Various illuminometers with calibrated scales are on the market for making these measurements readily, the best of which from a practical point of view is the Macbeth illuminometer.

Still more convenient, if less accurate, are the various light meters, based on the reaction of the photoelectric cell to intensity of light. These can be used for a rough measure of the illumination at any plane, but since they are not provided with a checking device and their response to intensity of light varies with age and use, they cannot be relied on for more than a rough estimate without being frequently rechecked. Also, they are not applicable to light of a spectral composition differing from that for which they were calibrated. It cannot be denied, however, that they provide a convenient "vest pocket" means of obtaining an approximate estimate

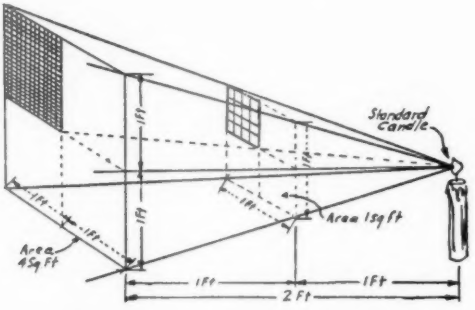

FIGURE 1.—Diagram illustrating the inverse square law. The amount of light received on a surface 2 feet distant from a standard candle is $\frac{1}{2^2}$ or one-fourth (¼) the amount received at 1 foot.

of the illumination given by tungsten lamps, for which they are customarily calibrated. Owners of a photoelectric photometer should be cautioned that such an instrument is an extremely delicate mechanism which should be handled gently. Failure to heed this caution will soon result in an instrument which is badly out of adjustment. With gentle treatment and frequent calibration against known standards, these devices serve a useful purpose.

Illuminants

Practically all light comes from one of two sources: incandescent bodies and luminescent bodies. By far the greater portion of light used at present comes from incandescent sources. This includes sunlight, electric filament lights, arc lights and all flame sources.

Such light is accompanied by a high percentage of infrared radiation and, the amount depending on its temperature, some ultraviolet radiation. All hot bodies are inefficient sources of visible radiation.

Luminescence—light from cold bodies—is the only efficient source of visible radiation. Luminescence may be classified as follows:

1. Electroluminescence, light from cathode rays, at present is not important except for special work. This source will probably be of greater importance in the future.

2. Triboluminescence, light produced by friction and crushing, is of no practical importance.

3. Chemoluminescence is light arising from chemical action, such as the bioluminescence of fireflies and sea animals. The oxidation and reduction of the luciferin-luciferase system holds promise of future application to human needs.

4. Photoluminescence, light produced by transformation from short wave radiations into visible radiations, includes fluorescence (light produced during activation) and phosphorescence (light continuing after activation has ceased).

The most widely used form of luminescence is exemplified in the present fluorescent tube lamps, introduced in 1938. These consist essentially of a glass tube with an electrode sealed in each end. An arc is produced by current flowing between these electrodes through mercury vapor contained within the tube when the lamp is connected to the proper power supply. This arc generates some visible radiation, or light, but much more invisible ultraviolet energy, which excites fluorescent chemicals coated on the inside of the tube. Unlike the ordinary incandescent lamp, the goal of fluorescent lamps is not to produce a maximum of light directly but, rather, to generate efficiently short wave ultraviolet radiation and then to employ fluorescent chemicals or "phosphors" which can effectively convert that ultraviolet energy into visible light. A low pressure mercury arc produces an abundance of one particular wavelength in this short wave ultraviolet region, 2,537 angstroms, and phosphors are selected and blended to respond efficiently at that wavelength. Various phosphors are used to produce different colors of light.[1]

Of general artificial illuminants present use is confined almost exclusively to gas-filled (type C) tungsten filament incandescent lamps and to fluorescent lamps. The latter have various advantages and disadvantages and will be considered separately.

Principles of Application

The ophthalmologist is most frequently requested to give advice as to the best kind of light and the intensities required. Such questions cannot be answered categorically, since the answers will vary with the person, the task to be performed, and the surroundings.

The enumeration of five general principles may here prove helpful to the ophthalmologist when he is called on to evaluate a lighting system or to give advice regarding lighting.

Intensity.—A whole library might be filled with what has been written on the subject of levels of illumination, usually to the neglect of other factors, and the end has not been reached. Several catalogues of job analyses and their illumination requirements have been published by the Illuminating Engineering Society,[2] the American Institute of Architects and other national organizations.

In general, over the last fifty years there has been an upward trend in the recommended levels of illumination, particularly for work involving fine discrimination.

In 1896 Katz reported that 0.4 footcandle was the best average illumination when speed of reading was involved, and argued that an illumination twenty-five times as intense as the threshold value was sufficient. Most authors up to 1912 recommended 2 to 4 footcandles as the optimum. In view of the lighting fixtures of those days, it is probable that the low intensities prescribed were conscious or unconscious attempts to eliminate excessive contrast or glare; moreover, light sources of high efficiency had not been developed.

Troland,[3] in 1931, after the most extensive review of the literature on this subject ever undertaken, concluded:

> . . . the vast majority of industrial operations can be carried out at maximum efficiency with an illumination intensity in the neighborhood of 10 ft-c and many of these operations can be done equally well at 1 ft-c where contrasts and sizes of details to be perceived are not of threshold dimensions.

These conclusions were strongly opposed to numerous recommendations made in the past decade, chiefly by Luckiesh and his associates at the General Electric Corporation, who argued for levels fifty to one hundred times as high as those formerly considered optimum. The argument reached the lay press,[4] and charges were aired that the high recommendations were commercial propaganda.

The answer lies in the great range of adaptability of the human eye, which can function efficiently probably over a range of 10,000:1. It is unfortunate that so much publicity and emphasis have been given to this single factor of intensity. Ophthalmologists who are interested in getting details for a specific problem are advised to obtain a copy of the "American Recommended Practice of School Lighting" (or "American Recommended Practice of Industrial Lighting")[2] from the Illuminating Engineering Society. In these booklets high conservative levels are given for almost all tasks.

The effect of changes of illumination on ocular fatigue in the zones ordinarily encountered, that is, between 10 and 30 footcandles, is relatively unimportant. It is certain that continued use of the eyes, especially for fine work, under values of an order of 1 per cent of these intensities will result in eyestrain and functional inefficiency, with possible organic damage. A corresponding increase in these intensities to hundredfold values of artificial illumination will probably also result in eyestrain and ocular fatigue unless adjustment is made in the quality and distribution of the light.

Quality.—The quality, or spectral composition, of light is an important attribute so far as its effect on ocular efficiency and comfort is concerned. Most authorities agree that the more nearly the quality of the light approaches diffuse daylight, the better it is. In work involving color discrimination such spectral quality is essential. Tungsten filament light is relatively deficient in green, blue and violet radiation as compared with daylight. This invalidates it for color judgments, but for all ordinary purposes it serves well. Visual acuity is good under this light, and the preponderance of yellow radiations leaves it not unpleasing or uncomfortable to most

people. There are some persons, however, who find themselves able to work longer and with less fatigue under artificial daylight. Both of us belong in this group, and we recommend artificial daylight for others so constituted. The units manufactured by the Macbeth Daylighting Company will be found satisfactory for persons who are comfortable when working or reading under daylight but who experience discomfort when using tungsten lamps. We know of no other commercial artificial daylight product of which this can be said. The "blue bulbs," so-called daylight bulbs, do not yield light of daylight quality, or even approach it. They represent perhaps a 15 per cent step in the direction from Mazda to north skylight. For the sake of precision, we should state the quality of our illumination in terms of one of the three internationally standardized illuminants —illuminants *A*, *B* and *C* of the International Commission on Illumination. The first, illuminant *A*, may be taken as a qualitative standard of tungsten filament light in units of 200 watts or above. Illuminant *B* may be taken as the qualitative standard for white light or sunlight of apparent color temperature near 5,000 K., and illuminant *C* is the standard for "daylight" lamps, approximating light overcast skylight of a color temperature between 6,500 and 7,000 K.

Contrast.—An important factor in evaluating or prescribing lighting is the contrast involved in the work being done. High contrast means increased visibility. Black on white can be discriminated very well under low illumination, whereas low contrast work requires more light. This is readily exemplified when one considers the relative visual work required to sew with black thread on black cloth and that involved in sewing with the same thread on white cloth. In the first instance a great increase in illumination is required to offset the disadvantage of low contrast. Contrast is frequently evaluated as per cent and fitted into lighting prescriptions on that basis.

For example, printing ink reflects little (approximately 4 per cent) of the light incident on it. Good white paper reflects about 80 per cent of the light incident on it. The contrast of such ink and paper, then, is 4 per cent on 80 per cent, or 76/80, which equals 95 per cent. If the ink reflects 8 per cent, the percentage contrast is

8 per cent on 80 per cent, or 72/80, which equals 90 per cent. In evaluating the illumination to be used in reading, the following illustration may be used: The material is printed in 8 point type, with an average blackness of 8 per cent (reflectance). The paper has an 80 per cent reflectance. The brightness contrast is therefore 90 per cent. For such reading an illumination of 10 to 15 footcandles is recommended. This level should be increased if (1) the visual angle is smaller, as with 6 or 4 point type; (2) the contrast is less, as when the paper is old, yellowed, smudged or of poor quality; (3) speed and accuracy are needed, as in proof-reading; (4) the subject has poor eyes or a refractive error; (5) the subject has poor visual acuity with the best possible correction, or (6) the work requires prolonged periods of concentration. Good lighting in such a case increases visual efficiency, speed of seeing and comfort.

Distribution.—Distribution is an important factor in good lighting. Glare and its evil consequences, although a result of faulty distribution, will be considered separately. The distribution of light in the field of vision affects all the component visual functions, as well as the integrated act itself. However optimal other conditions may be, extreme variations in intensity occurring in the field of vision produce disturbing effects on the eye, and the disturbance is directly proportional to the size and intensity of the disturbing source and its proximity to the line of sight. Under certain conditions these extreme contrasts are desirable, as when an object near the threshold of acuity must be made visible, but in general pronounced and useless differences in brightness in the field of vision contribute to ocular inefficiency and the production of fatigue. This is especially true when the eye in its movements must subject the central portion of the retina to frequent and sudden changes in intensity of stimulus; the inability of the macula to meet these demands for repeated rapid adjustment results in temporary partial blindness—central scotoma. For greatest comfort the entire field of vision should be well and evenly illuminated with perhaps a mild increase in the area of the working plane.

Unsteadiness of illumination is another source of fatigue, by producing incessant demands on the eye for readjustment. Under certain conditions, such as flicker, it is quickly and unpleasantly

effective. Cloud or smoke shadows frequently cause rapid and annoying alterations in light values near windows.

Diffusion is related to distribution and shares its importance. Diffuse light does not cast sharp, dense shadows. As with contrast, under certain conditions these sharp shadows may add to visual efficiency, but these special conditions do not detract from the general statement that the more diffuse the light the better it is tolerated by the eye. Lancaster has characterized diffusion as an important quality of good lighting and has indicated a rough test for this quality: A pencil held a few inches from the paper, book or work to be viewed should not, and will not, cast a sharp shadow if the light is properly diffused.

Glare.—Glare is a factor in faulty distribution. Glare has been defined as useless light in the field of vision. Its importance increases as it approaches a position on the line of sight. Glare may be diffuse, specular or direct. Diffuse glare is the type experienced outdoors from too high intensities. Specular glare is the type produced by mirrors, highly polished metal and furniture, glossy paper and other shiny surfaces. Light specularly reflected from an object is not focused into an image on the retina. It is represented merely by a spot of unfocused light. If focused, it would form an image of the source of light, not of the reflecting object. However, in looking at an object one focuses for it, not for the source of light. Light diffusely reflected, since it begins its effective origin at the reflecting surface, forms an image alone of that surface on the retina. One thus sees objects only by diffusely reflected light. The light specularly reflected, since it forms an overlay of unfocused light on the image, blurs that image and is therefore not an aid, but a hindrance, to vision. There are three methods by which one may combat this type of glare: (1) The direction of the light may be changed; (2) the light may be completely diffused, or (3) specular reflection may be eliminated, partially at least by Polaroid. Of the three methods, the first is the most practical and least expensive. Rhoads[5] gave a test for this type of glare: A fairly large mirror is placed on the working plane or where a book is to be held for reading. If any light sources can be seen in the mirror, then the working plane, the position of the body or the light source should be adjusted until the

reflections disappear. Another method by which one may ameliorate, though not wholly avoid, such specular reflection is to make the light sources as extensive as feasible, thereby permitting a reduction in their intrinsic brilliance without reducing the illumination.

Direct glare arises from bright objects in the field of vision, such as headlights out of doors or unshaded lamps indoors. The unpleasant effects of such sources of glare are, as already stated, directly proportional to the brilliance of the object and its proximity to the line of sight, so that a 100 watt lamp 10 degrees from the line of sight will produce about as much glare as a 200 watt lamp 15 degrees from the line of sight. In order to avoid or reduce glare,

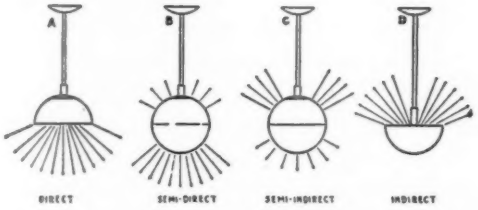

FIGURE 2.—TYPES OF LIGHTING FIXTURES. In this figure *A* shows direct lighting; *B*, semi-direct lighting; *C*, semi-indirect lighting; and *D*, indirect lighting. Three decades ago most lights had either no fixtures or were equipped with fixtures of type *A*. At present luminaires are preponderantly of type *C*.

the brilliance of light sources should be kept as low as possible. Reduction in the brilliance of the source will reduce the illumination unless compensation is made, and this compensation takes the form of increase in the area of the source. Hence large sources of low intrinsic brilliance, achieved through luminaire design, diffusing glasses or semi-indirect lighting, are distinctly preferable to small, bright sources (fig. 2). The whole evolution of lighting engineering in the past two decades has been in this direction. An excellent rule for one to follow in evaluating or prescribing such compensation is that the brightness of the source shall not be more than twenty (preferably ten) times the brightness of its background and, further, that the intrinsic brightness of the source shall not exceed 3 (preferably 1) candles per square inch.

A few rules of thumb suggestions may be helpful to one in evaluating or prescribing for an illumination situation:

1. The intensity of light, or the illumination level, is to be selected with reference to the patient and the nature of the work he is to do.

2. The quality is evaluated with reference to the task to be performed and the patient's preferences. Illuminant C, standardized by the International Commission on Illumination, is mandatory for most work involving color judgments and is preferred for general purposes by a large number of subjects.

3. The conditions of contrast have an important bearing on the intensity and quality recommended.

4. The distribution should be as even and diffuse as possible. Pronounced differences in brightness should be avoided. The Lancaster test for diffusion is helpful.

5. Glare is to be looked for and ameliorated or avoided. The Rhoads test for specular glare is helpful.

The background is to be kept diffusely illuminated. A good rule is that the ratio of illumination of the working plane to the background shall not exceed 4:1, and preferably should be less. The ratio of brightness of the source to that of the background should not exceed 20:1, preferably 10:1, and the intrinsic brilliance of the source should not exceed 3 (preferably 1) candles per square inch. In order to achieve an evenly diffuse illumination of 15 to 20 foot candles in a room with light walls and ceilings, there will be required (if a tungsten filament type C illuminant is used) about 2 to 3 watts per square foot of floor space. Higher general levels are rarely required and should not be recommended except under special circumstances, since the excessive infra-red radiations of such sources (90 per cent) would cause unpleasant heating in the summer time and might necessitate air conditioning.

Fluorescent Lighting

The ophthalmologist will frequently be requested to give advice concerning the fluorescent tube lighting, introduced in 1938. This type of lighting has been growing in use and importance. In spite

of six years of development, much is to be desired, and it is too early to give an unqualified opinion. It is obvious that one great fault has been inadequate design of fixtures to hold these tubes. The present period may be analogous to the middle teens, after the introduction of the gas-filled, unfrosted Mazda lamp. The present fluorescent tubes are too bright for comfort when unshielded, and most installations carry little or no shield. The intrinsic brightness of the 30 watt Mazda F lamp is 5.5 candles per square inch for the 3,500 degree white light tube and 4.5 candles per square inch for the daylight tube. All Mazda fluorescent tubes, except for the 14 and 15 watt types, have a brightness of over 3 candles per square inch.

When the lamp is used close to the work, as a desk lamp in the usual position at the back of the desk, the glare from specular reflection is pronounced. This fault is partially obviated if the lamp is placed along the side of the desk or table, on the left side for a right-handed person and on the right side for a left-handed person.

The advantages of the fluorescent tubes are their high lumen per watt efficiency and the flexibility, within a limited range, with which their color value can be changed.

They do not, however, and probably cannot be made to, give the spectral curve of daylight, and time and experience are necessary to show whether deviations in this respect are deleterious. The fluorescent tubes are best suited for installations in large areas and are particularly useful in air-conditioned interiors because of their relatively low heat output. They should always be mounted high. Their recommendation for small rooms in the present state of development of the lamps and fixtures is questionable.

Many people, sensitive and insensitive, work happily, efficiently and comfortably under fluorescent lighting. Many others, and they are not neurotic or reactionary persons incapable of absorbing new ideas, have experienced discomfort and great unpleasantness since the installation of fluorescent lighting. Common complaints are ocular fatigue, burning of the eyes, headache, tearing and a feeling of sand in the eyes.

At the Knapp Memorial Laboratories, where studies on fluorescent lighting have been carried out, we have been inclined to explain the unpleasant effects of this type of lighting in terms of six

factors: (1) flicker, either (a) total or (b) electrode; (2) spectral quality; (3) high intrinsic brightness; (4) radiation of wavelength of 312 to 313 millimicrons; (5) lag of emission in the blue-green-yellow portion of the spectrum, and (6) stroboscopic effect.

The total flicker is usually due to insufficient voltage or to deteriorated lamps, although electrode flicker has frequently been seen when neither of these factors was apparently present. The spectral quality, we are sure, affects color vision and may produce unpleasant psychologic effects. Probably the chief difficulty arises from the high intrinsic brightness, which varies from 5.5 candles per square inch, in the 30 watt white light tube, to 3.3 candles per square inch, in the 40 watt daylight tube. We strongly believe that intrinsic brightness should be kept below 3, preferably 2, or even 1, candles per square inch. We feel sure that diffusing covers for fluorescent tubes will be used more and more in the future.

Fluorescent tubes emit a fairly strong double line at 312 to 313 millimicrons. Some of this radiation may pass through the glass of the tube. Quantitative measurements are at present under way to evaluate this factor, which may prove to be important. Ultraviolet radiation of this wavelength might have two effects. Such rays are abiotically active, and since the effect of such radiation is cumulative, prolonged exposure might result in irritation of the cornea and conjunctiva. Another, and so far unconsidered, effect is the intraocular fluorescence which might be produced if this radiation reaches the lens of the eye; in this case the overwash of fluorescent light generated within the eye might be very unpleasant.

The lag of emission of the blue-green-yellow components from a fluorescent tube results from the difference in excitation periods of the various phosphors used in coating the tube and may easily be demonstrated by observing such a tube in action through a stroboscope. There is a large, brief, blue peak, followed by other component colors. Whether this "blue beat," or the lag of emission of the other colors, has any visual, physiologic or psychologic significance is not yet known.

Finally, the well known stroboscopic effect of fluorescent lights makes them unpleasant for the illumination of rapidly moving machine parts. This effect can be partly overcome by use of multiple, out of phase tubes, but the best ratio so far achieved has been

3 to 1 (a Mazda incandescent lamp being used as 1). Fluorescent lighting should not yet completely displace the more conventional types.

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Note and Comment

Society Co-operates in Conference on Industrial Ophthalmology at Columbia University.—We are gratified to be able to announce the Society's participation in the Conference on Industrial Ophthalmology held by the College of Physicians and Surgeons at the Columbia University School of Medicine. With the enthusiastic endorsement of the United States Public Health Service and the War Production Board, the College of Physicians and Surgeons, in co-operation with the National Society for the Prevention of Blindness, had asked representatives of the department of ophthalmology from the medical schools of the nation to come together to consider what steps may be taken, especially by the medical schools, to provide ophthalmologists trained in the industrial aspects of ophthalmology. Seventy ophthalmologists and other professional educators, representing the leading medical schools in the United States, participated in the Conference, and all indicated marked interest in the variety of topics presented. The topics discussed included: "Eyesight in Industry," by Charles P. Tolman; "Industrial Challenge to Ophthalmology," by Albert C. Snell, M.D.; "Elementary Illumination for the Ophthalmologist," by Gertrude Rand, Ph.D.; "Improving Seeing Conditions," by W. G. Darley and A. K. Gaetjens; "Job Analysis and Refracting and Prescribing for Special Work Distances," by Hedwig S. Kuhn, M.D.; "Job Analysis for Visual Requirements," by Joseph Tiffin, Ph.D.; "Industrial Hazards and Protective Devices," by Charles P. Tolman; "Comments on the Practical Application of Protective Devices," by J. E. Mercure; "Symposium on Screening Methods for Industrial Visual Characteristics," by Conrad Berens, M.D., Chairman, with discussion by Dr. Berens and Joseph Lo-Presti, M.D.; "Current Studies on Tests for Defective Color Vision, and Demonstrations of Screening and Diagnostic Color Vision Tests," by LeGrand H. Hardy, M.D.; "The Use of Color for Simplifying the Visual Task," by Faber Birren; "Welding Hazards," by Lt. Commander Walter L. Fleischer, M.D.; "Vision Engineering Management," by L. Holland Whitney, M.D.; "Industrial Toxic

Compounds, Hazards and Treatment," by Charles F. Kutscher, M.D.; and "Industrial First Aid in Chemical Injuries of the Eye," by James M. Carlisle, M.D. Full proceedings of the Conference will be published and available at a later date.

It is expected that this program will stimulate interested groups in regional conferences and that more satisfactory graduate instruction in industrial ophthalmology in the medical schools throughout the country may result.

British Institute of Ophthalmology Established.—At the Royal Eye Hospital in London, an Institute of Ophthalmology has been established, where teaching and research can be systematically carried on and co-ordinated with the work of laboratories and of other ophthalmic and general hospitals. The need for such research is evident from the fact that there are over 75,000 registered blind in England and Wales, and the annual expenditure on blind welfare by local authorities amounts to over £2 million. The founding of the Institute is part of a new impetus toward ophthalmic research, heralded by the University of Oxford's request some months ago, for the founding of a department of ophthalmology, and by the appointment of Professor A. Sorsby to the first full-time ophthalmic research post in England: the new research chair in ophthalmology at the Royal College of Surgeons and the Royal Eye Hospital.

Ophthalmological Work in Cantonment Type Hospital.—Reporting in the *Military Surgeon*, Lt. Col. Alfred B. Berkove, U.S.A., presents a survey of over 7,000 patients treated for eye diseases during a year's period in a large cantonment type station hospital, giving these statistics: 85 per thousand patients examined were treated for external eye diseases; 12 per thousand were treated for internal eye diseases. In this series of more than 7,000 case records studied, three men were separated from the service for chronic external eye diseases, and 20 for internal eye diseases.

The Eye-Bank for Sight Restoration.—Teaching and research fellowships to extend the knowledge and skill required for the delicate operation which restores sight to a blind person with a corneal defect through the grafting of healthy corneal tissue will be

established in leading medical schools throughout the country by The Eye-Bank for Sight Restoration, Inc., it was disclosed here today by Mrs. Henry Breckinridge, executive director. To carry on this program of education and research, as well as its other activities, The Eye-Bank will undertake to raise $1,000,000, Mrs. Breckinridge announced at national headquarters, 210 East 64th Street.

An initial grant of $25,000 has been made by the Milbank Memorial Fund to enable The Eye-Bank to function pending the time when the importance of the undertaking may gain recognition and widespread support. It is hoped that financial support will be forthcoming from the general public in sums of any amount.

In a statement accompanying Mrs. Breckinridge's announcement, Albert G. Milbank, president of the Milbank Memorial Fund and chairman of the Advisory Council of The Eye-Bank, expressed "the hope and expectation that The Eye-Bank for Sight Restoration, Inc., will make important contributions to public health by advancing our knowledge of the pathology of the eye, thus making the prevention of eye diseases more effective, by improving or restoring the sight of persons who are handicapped by corneal opacities, and by its educational procedures which should arouse interest in sight conservation among physicians, specialists and the public."

Outstanding ophthalmologists are participating, in an advisory capacity, in The Eye-Bank's work of collecting and preserving healthy corneal tissue from human eyes for transplanting to blind persons who have lost their sight because of corneal defects. The operation substituting a healthy cornea for a damaged one can restore sight in only one type of blindness—that caused solely by opacity of the cornea when the rest of the eye and optic nerve are normal; it is estimated that between 10,000 and 15,000 blind persons in the United States may have an opportunity to see again through the "corneal transplant" technique.

"Blindness caused by injury to the cornea, through disease or accident, strikes men, women and children of all ages, rich and poor alike," Mrs. Breckinridge pointed out. "At the present time, corneal tissue taken from the eye of a living or dead person may be stored for only three days before transplanting. One of the principal

objectives of the research to be sponsored by The Eye-Bank is the discovery of a method of preserving corneal tissue for a longer period.

"Ophthalmologists are giving devoted service in an effort to restore sight to the blind whenever it is possible, but we also need understanding and financial support from the public. In addition to money, we need the consent of those persons who may be willing to have their corneal tissue used, after death, to help the blind see again."

Grant Made for Glaucoma Study.—From the *Journal of the A.M.A.* we learn that the Snyder Ophthalmic Foundation has given a grant of $6,500 a year for a period of two years to the Toledo Hospital Institute of Medical Research for research on the physiology of the eye, especially in relation to glaucoma. The grant will be extended depending on the results obtained in the first two years. According to Dr. Bernhard Steinberg, Director of the Toledo Hospital Institute of Medical Research, the work will be delayed until after the war, when a physiologist with specialized training in the eye will become available.

I.E.S. Recommended Practice of Home Lighting.—The first official "Recommended Practice of Home Lighting" has recently been released by the Illuminating Engineering Society. The report, developed and prepared by the Society's Committee on Residence Lighting, will be available soon as a 40-page, 6 x 9 illustrated booklet, with cover. It constitutes an authoritative guide for the lighting of all of the major rooms and various seeing tasks in the home. Its recommendations are based on the findings of home lighting specialists of many years' experience and represent the most comprehensive and official study of this subject heretofore published.

In addition to the fundamentals of adequate lighting, the report covers such subjects as color and its relation to light, fluorescent and filament sources in the home, built-in lighting, placement of lamps, and includes also a table of footcandle recommendations for numerous seeing tasks in the home. Each room in the home is studied separately and specific recommendations made for its

lighting, including drawings of suggested light-fixture types. Thirty-six illustrations included in the booklet graphically demonstrate the beauty and excellent seeing conditions achieved by the lighting recommendations presented.

It is expected that "Recommended Practice of Home Lighting" will be of especial value to architects, interior designers and decorators, home economists and many others interested in the welfare and comfort of the American family.

"Perfect Sight Without Glasses."—The Federal Trade Commission declares the book "Perfect Sight Without Glasses" to be a misrepresentation, and to have been advertised through unwarranted statements. The Commission's greatest objection to the book is that credulous readers may rely upon its false promises instead of consulting a trained eye specialist. The author, a woman, has been cited to appear before the Commission to answer charges.

Pan-American Congress of Ophthalmology.—Dr. Harry S. Gradle, president of the second Pan-American Congress of Ophthalmology, while on his recent speaking tour in South America, found all preliminary arrangements and programs completed for the next meeting of the Congress, scheduled for November 25 to 30, 1945 in Montevideo, Uruguay, with all the leading ophthalmologists in Latin America enthusiastic about this coming event. The National Society, in response to an invitation, is planning to present at the Congress an extensive exhibit, in Spanish, which will subsequently be available to all the Latin American countries for local showings.

Memorial for Dr. Jackson.—In memory of the late Dr. Edward Jackson, for many years editor of the *American Journal of Ophthalmology*, and a member of the National Society for the Prevention of Blindness' Board of Directors, a lecture series has been established under the sponsorship of the *Journal*. The first lecture, presented by Dr. William H. Crisp, Denver, during the 1944 Annual Meeting of the American Academy of Ophthalmology and Otolaryngology, was entitled "Edward Jackson's Place in the History of Refraction."

Women Exercise Care in Industry.—Having tabulated and analyzed work injuries to women in shipyards, 1943–44, the Industrial Hazards Division, Bureau of Labor Statistics, U. S. Department of Labor, reports, in part:

Women score decidedly better than men in use of protective equipment. Injuries caused by failure to wear goggles constituted, in the case of women, 11.9 per cent of all injuries; in the case of men, 18.8 per cent.

In four shipyard departments studied, men suffered more eye injuries due to foreign particles than did women: in welding, the percentage was nearly three times as frequent in men; in assembly and sheet-metal work, over four times; in electrical work, where such hazard is slighter, 5.2 per cent of injuries to men were due to foreign bodies, 3.5 per cent of injuries to women. In three departments men suffered a greater percentage of welder's flash; only in assembly work did the women's percentage exceed that of the men.

Kansas Expands Sight Conservation Program.—The Kansas Medical Society's committee for the conservation of eyesight made two important decisions regarding patients referred through the Division of Service for the Blind. First, it approved a new plan of operation related to the patient's employment. This does not materially change the present set-up, but does make Federal funds available. Secondly, the committee recommended that the Division of Service for the Blind expand its program to include all types of medical eye surgery and treatment necessary for the comfort, as well as restoration of eyesight and prevention of blindness for the indigent blind.

American Board Examinations Postponed.—The American Board of Ophthalmology has announced that, due to transportation difficulties, the examination of the Board has been postponed from October to January, 1946. The 1946 examinations will be held in Chicago on January 18 through 22; in Los Angeles on January 28 through February 1; in New York in May or June; and in Chicago, in October.

Research on Eye Protectors.—The American Society of Safety Engineers, Engineering Section of the National Safety Council, is

sponsoring a new program of research into the performance requirements and specifications of plastic eye protectors. The research, which will include both laboratory and statistical investigations, has been started at Battelle Institute, Columbus, Ohio, one of the largest foundations for industrial and scientific research in the United States.

Puerto Rico Campaigns for Sight Conservation.—The Department of Public Welfare reports that during 1944 the Office of the Handicapped, with the co-operation of the executive secretary of the Vocational Board for the Adult Blind, intensified its educational campaign for the prevention of blindness among school children.

Safety Program Pays.—The Boeing Airplane Company, Wichita Division, in order to stimulate the wearing of protective eye equipment, instituted a combination education and service plan designed for this purpose. The educational program was carried on through the showing of safety motion pictures, and bulletin board displays explaining the uses of nine types of eye protective equipment. The service part of the plan was inaugurated with a thorough reconditioning of all safety equipment (some equipment was temporarily discarded awaiting repairs, and other, still available, was so badly soiled that workers avoided using it). A special service plan was put into operation, through the employment of representatives who could immediately answer any trouble report about glasses or goggles. This on-the-spot service is paying big dividends in a steadily decreasing eye accident rate.

New Ophthalmological Society in Illinois.—A new organization to be known as the Central Illinois Society of Ophthalmology and Otolaryngology has recently been formed. The group's expressed aims are to promote the profession of ophthalmology and raise its standards. Membership in the Society is limited to 50, although any eye, nose, and throat practitioner may attend meetings as the guest of a member. The meetings are to be held three times a year, at which time papers will be presented by the most eminent men in the profession.

Winifred Holt Mather—In Memoriam.—Everyone engaged in sight conservation or work for the blind mourns the death of Mrs. Winifred Holt Mather, an honorary Vice President of the National Society, and one of its original founders. In 1906 when the Governor of the State of New York appointed a Committee to Investigate the Conditions of the Blind in New York State, Mrs. Mather, then Miss Winifred Holt, and her sister, Edith, volunteered to assist in the taking of a census of the blind in New York State. The report was finished and transmitted to the Legislature on April 10, 1907. This report aroused the interest of Miss Louisa Lee Schuyler who met with the Holt sisters, Dr. Park Lewis, Mr. John M. Glenn, and several other socially minded persons, to create the first New York State Committee for the Prevention of Blindness, which developed into the National Society of today. While maintaining an interest in the work of the National Society, Mrs. Mather with her husband, Mr. Rufus Graves Mather, devoted themselves throughout the years to the welfare of the blind, stimulating the establishment of many of the Lighthouses throughout the world. No more lasting monuments to Winifred Holt Mather's memory could be erected than these institutions which she was so instrumental in founding.

Local Agencies Suffer Loss.—It is with regret that we learn of the death of two workers in prevention of blindness during the past few months: Mr. Gayle Burlingame of the Pennsylvania State Council for the Blind, and Mr. Henry P. Johnson of the Florida Council for the Blind. Their communities will long feel their loss.

Current Articles of Interest

Choice of Sulfonamide in Ophthalmia Neonatorum, A. Sorsby, M.D. and Elizabeth E. Hoffa, M.D., *The British Journal of Ophthalmology,* March, 1945, published monthly by The British Journal of Ophthalmology Ltd., 24–27 Thayer St., W.1., London.

This article presents a review of 333 cases of ophthalmia neonatorum which were treated with the regulation dose of five different sulfonamides. The authors conclude that the least tolerated drug is sulfanilamide, and that sulfapyridine is less well tolerated than sulfamezathine, sulfathiazole or sulfadiazine, although these five sulfonamides vary little in effectiveness, with 30 to 40 per cent of the cases being cured within three days and over 8 per cent cured after eight days; gonorrheal ophthalmia neonatorum responded most readily.

Nonmagnetic Intraocular Foreign Bodies, Harvey E. Thorpe, M.D., *Journal of the American Medical Association,* January 27, 1945, published weekly by the A.M.A., 535 North Dearborn Street, Chicago.

Considering the increased number of combat and industrial eye injuries resulting from the war, Dr. Thorpe stipulates conditions which should lead the ophthalmologist to suspect a foreign body, evaluates methods of locating it, and proceeds with discussion of techniques in its removal. He concludes that: Prompt removal is important; chemically inert foreign bodies need not be disturbed unless mechanically irritating; identification of nonmagnetic foreign bodies can be aided by careful history-taking and examination of tools employed in the injury; the globe must not be mutilated simply to remove a foreign body which might be inert; one should not grope in the vitreous with any instrument; retinal detachment must be properly and promptly treated; and sympathetic ophthalmia should be borne in mind in every perforating case.

The Goal of an Eye-Hygiene Program for School Children, James J. Regan, M.D., *The Journal of School Health*, May, 1945, published monthly by the American School Health Association, 3335 Main Street, Buffalo 14, New York.

The author believes it is of great importance that some very definite program, directed toward the maintenance of eye health, should be developed within the school system through an educational program sponsored by a joint committee of the state departments of health and of education. He suggests that the program take whatever form local facilities permit and whatever support local school authorities provide.

Trachoma in West African Negroes, Major J. Graham Scott, R.A.M.C., *The British Journal of Ophthalmology*, May, 1945, published monthly by The British Journal of Ophthalmology Ltd., 24–27 Thayer St., W.1., London.

Trachoma of the West African Negroes, according to the author, is a mild disease and generally of the infiltrative type, affecting a small percentage of school children and soldiers and a larger percentage of village inhabitants (in some cases up to 25 per cent) in the Gambia. The American Negro soldiers do not have the infection, but are not immune.

The Royal Air Force Mobile Eye Surgery, Air Commodore P. C. Livingston, O.B.E., A.F.C., F.R.C.S. *Journal of the Royal Institute of Public Health and Hygiene*, December, 1944, published monthly by the Royal Institute of Public Health and Hygiene, 28, Portland Place, London, W.1.

The Mobile Eye Surgery, installed in a converted ambulance, is so designed as to permit within a compact unit a wide range of function, including: clinical examination; refraction and fitting of spectacles; operations; and the study of nutritional deficiencies as they affect the eye.

The Incidence of Eye Disease in the Australian Imperial Forces, Middle East, Major J. Bruce Hamilton, A.A.M.C., *British Journal*

of Ophthalmology, August, 1944, published monthly by the British Journal of Ophthalmology, Ltd., 24–27 Thayer St., London, W.1.

From private case records covering eight years, the author compiles a listing of 6,458 patients having 14,317 diseased conditions under 239 disease headings—a ratio of 2.22 diseases per patient. During 2 years in the Australian Imperial Forces he recorded 3,638 cases with 5,650 diseased conditions under 226 disease headings—1.55 diseases per patient.

The present report includes tables comparing incidence in civil as against active military life, of (1) eye diseases (2) eye injuries (3) visual disorders (4) muscle anomalies (5) keratitis. The author observes that (a) there is a lower percentage of eye injuries in war service than in civil life—9.4 per cent against 15.6 per cent, though the war figures include casualties from three active AIF campaigns; (b) eye diseases also seem to be more prevalent in civil than military life; (c) visual disorders and muscle anomalies were rather severe in the war group, reflecting a rushed recruiting; (d) virus keratitis cases in the Middle East were troublesome, caused often by some pyrexia, and were difficult to eradicate in that climate; (e) extremes of illumination, caused by climate in the field, were responsible for much eye trouble.

Treatment of disease in the AAMC is higher than that of the civil population, and therefore complications such as sympathetic ophthalmia occur rarely. In general the good showing of the military group was felt to be due to the efficiency and promptness of treatment by the medical staff.

Retinal Detachment: A Series of 78 Cases in the Middle East Force, H. B. Stallard, M.B.E., M.D., F.R.C.S., *British Medical Journal*, September 9, 1944, published monthly by the British Medical Association, Tavistock Square, London, W.C.

The summary of this article states: "This paper reviews 78 cases of retinal detachment occurring in officers and men of the Middle East Forces from 1941 to 1943. The cases have been divided into five groups according to the main feature of their pathology.

Seventy-six were operated on by the same technique; in one case operation was contra-indicated and another underwent spontaneous recovery.

"The prognosis is favorable in cases of retinal detachment due to cystic degeneration and to choroido-retinal degeneration. It is least favorable in war injuries. The reasons for this are discussed."

What Price Industrial Eye Comfort? W. G. Darley, *Illuminating Engineering*, December, 1944, published monthly by the Illuminating Engineering Society, 51 Madison Avenue, New York 10.

Mr. Darley recommends: Shielding brightnesses greater than that of the work; raising brightness of the work to that of the work area; using indirect lighting; painting shieldings a light color; assuring that close-up lighting of the work does not cause too great a discrepancy between it and the brightnesses of the surrounding area; and exercising even more care when using natural light than artificial.

Vision Problems of Military Students with Heavy Academic Loads. Ivor Clark, M. D., *The Journal-Lancet*, January, 1945, published monthly by the Lancet Publishing Company, 84 South 10th Street, Minneapolis 2.

Dr. Clark urges routine cycloplegia at the age of 10, and certainly before the undertaking of heavy academic work. In a study of 182 students of the Ohio State University Student Health Service, 126 were found definitely to need help, of which 66 had special features and were important as cases. Dr. Clark gives a brief description of the nature of these 66 cases, and concludes that "visual inefficiency is widespread among university students; this is the time for laying the foundation for the preservation of vision in the last two decades of life; cycloplegia should be used in vision testing for all students entering the university; special courses in visual education may be harmful if the greatest visual efficiency is not first assured."

Heredity and Eye Diseases, Olga Sitchevska, M. D., *Medical Woman's Journal,* October, 1944, published monthly by The Medical Woman's Journal, 528 Walnut Street, Cincinnati 2.

Heredity plays an important part in ophthalmology. A National Society for the Prevention of Blindness study of 1942 showed that about 14 per cent of all blindness and 10 per cent of adult blindness are due to hereditary factors, and the author feels that a full investigation would reveal that these figures are really low. Eye defects and diseases which are genetically dominant are: Congenital night blindness; blue sclerotics with fragility of the bones; ptosis; many types of cataract; dislocation of the lens; coloboma of the iris; aniridia (absence of iris); and familial types of corneal opacities. Examples of recessive traits are retinitis pigmentosa, albinism, anophthalmos, hydrophthalmos, and infantile glaucoma.

Ocular Neurosis, Squadron Leaders A. M. G. Campbell and A. G. Cross, R.A.F., *British Journal of Ophthalmology,* August, 1944, published monthly by the British Journal of Ophthalmology, Ltd., 24–27 Thayer Street, London, W.1.

Ocular symptoms with no organic lesions, or disproportionate to the pathological abnormality, naturally occur in greater degree under war conditions than during peacetime. This article discusses, under etiology, such causative factors as psychiatric predisposition; environment (occupational, climatic); ocular awareness (the one common factor of all cases); domestic stress; head injuries; strain of flying. Neurotic clinical manifestations included blindness and defective vision, asthenopia, photophobia and blinking, night blindness, and diplopia.

The authors emphasize the importance of careful examination and history-taking, both to exclude organic etiology and to instill confidence in the patient. Treatment of such cases will be really effective only when the patient's basic personality is sound. Strength of the reassurance must equal that of the neurosis; if this is not possible under war conditions, return to civil life is indicated.

It is suggested that incidence of ocular neurosis might be reduced

by greater public education in ocular hygiene and in the strength and potentialities of the normal eye.

The Function of the Eye in Aviation, V. Streltsov, *American Review of Soviet Medicine,* December, 1944, published monthly by the American-Soviet Medical Society, 130 West 46th Street, New York 19.

In order to increase the efficiency of pilots and to study the blood supply to the brain and eye, a system of special devices for training the eye has been worked out in the Institute for Physical Culture "I. V. Stalin" and the Central Laboratory of Aviation Medicine. The ocular function under flying conditions is disturbed by increased force of gravity, by high-powered sources of light such as searchlights. Experiments have been conducted with goggles; employment of pharmacological agents; increasing sensitivity by introducing measured doses of light into the eye. Working from the opposite starting point, examination was made of the influence of light effects, especially angle of light in the plane, on the discrimination of contrasts; of intelligent lighting of airports; of relation of decrease of color and light sensitivity to decrease in depth judgment. Results of physical exercise, of oxygen, are discussed.

Brightness, Well-Being and Work, H. C. Weston, *British Journal of Industrial Medicine,* July, 1944, published by the British Medical Association, Tavistock Square, W.C.1., London.

This extensive article discusses the various aspects of lighting in relation to industry. In conclusion, the author states: "The design of good factory lighting, whether natural or artificial, is the business of the illuminating engineer and the architect. But, while it is for them to understand and exercise the practical art of lighting—so as to fulfill the requirements which physiological and psychological considerations show to be necessary for a proper standard of well-being—it is not only for them, but clearly also for the industrial medical officer, to know what those requirements are. It is only with the latter that this paper attempts to deal, even in outline.

It is hoped, however, that it may assist those whose special function it is to promote in people at work healthy minds in healthy bodies, to assess conditions of lighting as they find them in the factory, and to point out in what respects improvement may be required."

Sympathetic Ophthalmia: Its Relation to War Injuries, M. E. Randolph, *War Medicine*, April, 1945, published monthly by the American Medical Association, 535 North Dearborn Street, Chicago, Ill.

The author states that whereas there is always the possibility of sympathetic ophthalmia occurring after the rupture or perforation of the eye globe, it actually develops in less than 2 per cent of all cases. The disease usually makes its appearance during the first two weeks following the injury, but may develop as soon as ten days or as late as three months. This article is devoted to giving the prescribed treatment for sympathetic ophthalmia, and to a discussion of the advisability of removing the injured eye.

Book Review

CATARACT AND ANOMALIES OF THE LENS. John G. Bellows, M. D., St. Louis: The C. V. Mosby Company, 1944. 624 p. ill.

An adequate review of this book is impossible. The mass of material presented is astounding, including embryology, anatomy, histopathology and biochemistry of the lens in the first five chapters. The latter half of the volume, which is devoted to clinical material, will probably hold more interest for the average ophthalmologist. Here the lens defects are grouped according to etiology as much as possible, and are presented in detail. The control of cataract by non-surgical means is fairly presented and fully discussed. The volume closes with a description of operative methods and their complications.

The material presented has never before been assembled in one volume, nor has it been so well co-ordinated anywhere. The purely clinical ophthalmologist will be well satisfied with his half of the volume; it will do him no harm to learn something about the other half.

The type is large and clear, on good stock; the illustrations—a few in color—are profuse. The bibliographies are exhaustive.

Dr. Bellows has produced a monumental work on the lens, which every ophthalmologist should own.

—WILLIS S. KNIGHTON, M.D.

Briefer Comment

JOBS FOR THE PHYSICALLY HANDICAPPED. Louise Neuschutz. New York: Bernard Ackerman, Inc., 1944. 230 p.

The author presents a list of vocations open both to the physically handicapped civilian and the wounded war veteran. In a practical manner, this is followed with a detailed description of the many possible methods of getting into the field of work selected. Unfortunately, the possibilities of work for the visually handicapped (not blind) are not included.

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